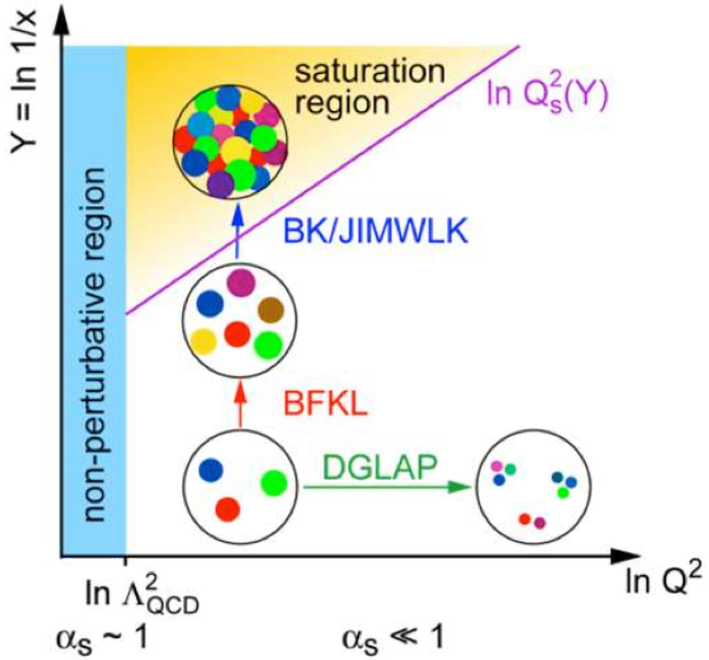
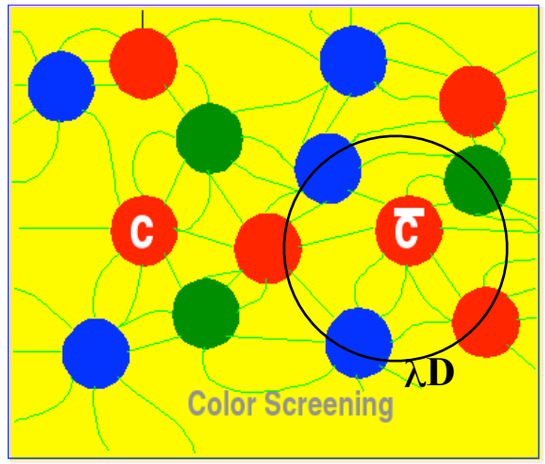




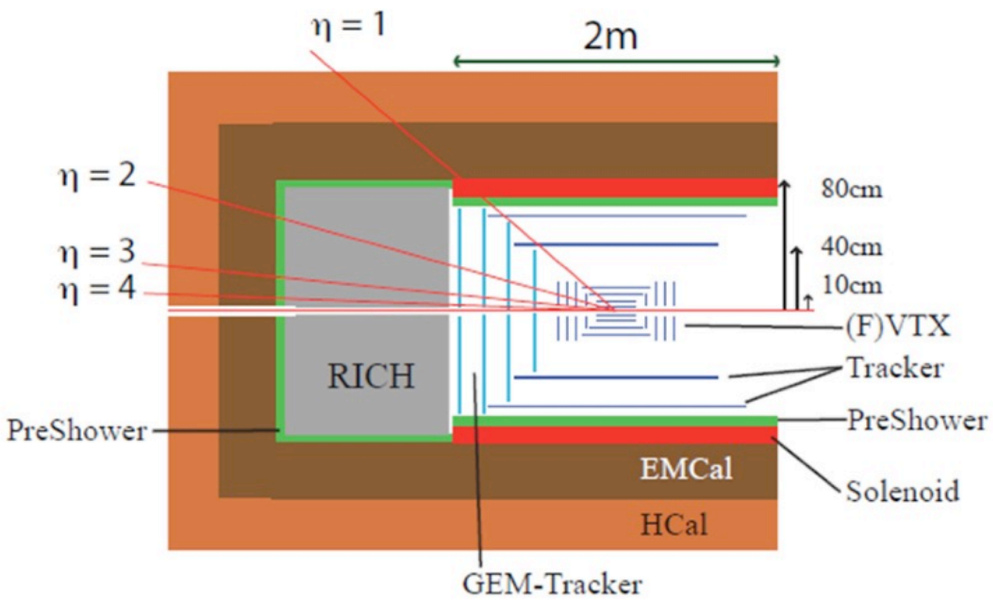
Los Alamos NATIONAL LABORATORY EST. 1943

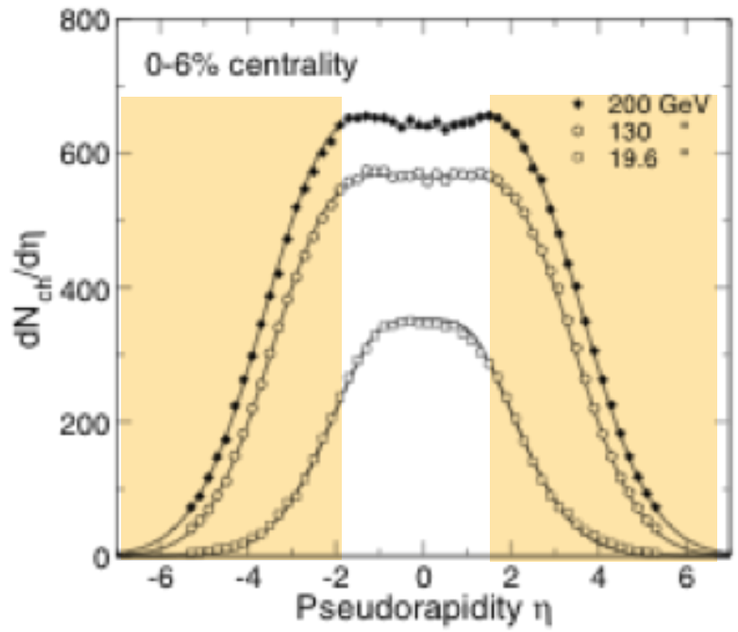
Heavy ion program for the near-term future

Cesar Luiz da Silva

Xiaodong Jiang

LANL Heavy Ion Review - Jan, 10 2012

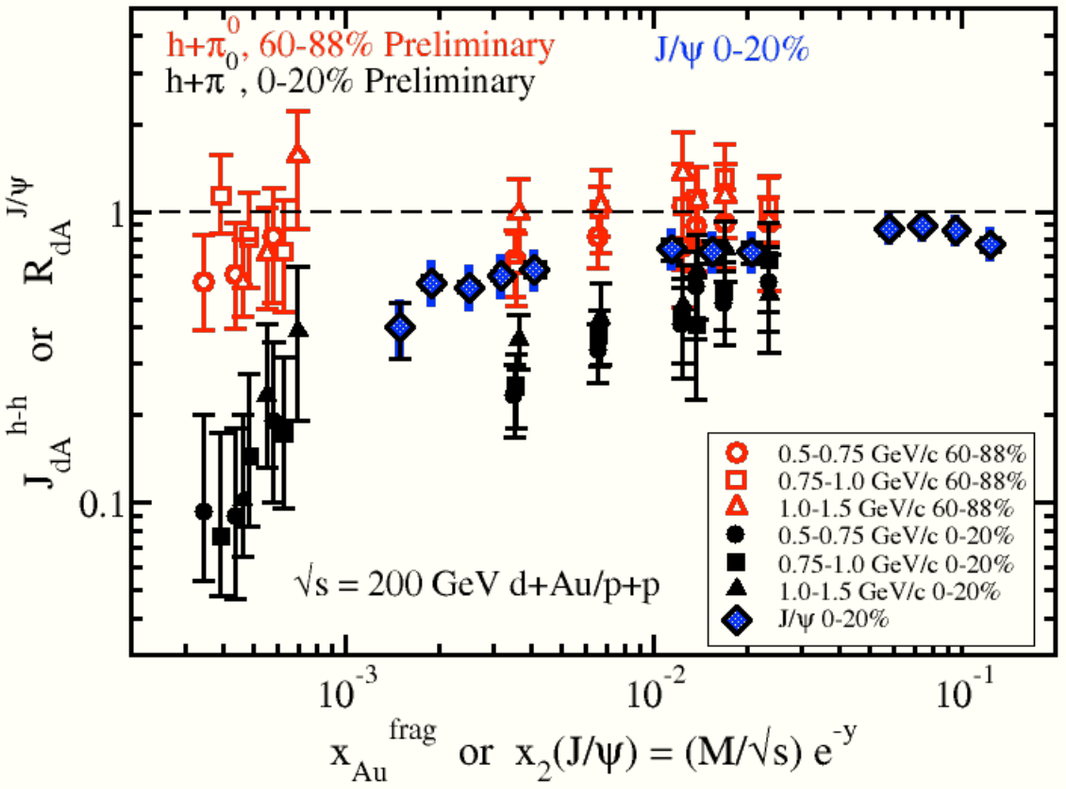




What we observed so far:CNM

started to explore kinematic regions where gluons with small fractional momentum (x) are suppressed when they are in a nucleus

$$x = \frac{p_{parton}}{p_{nucleon}}$$



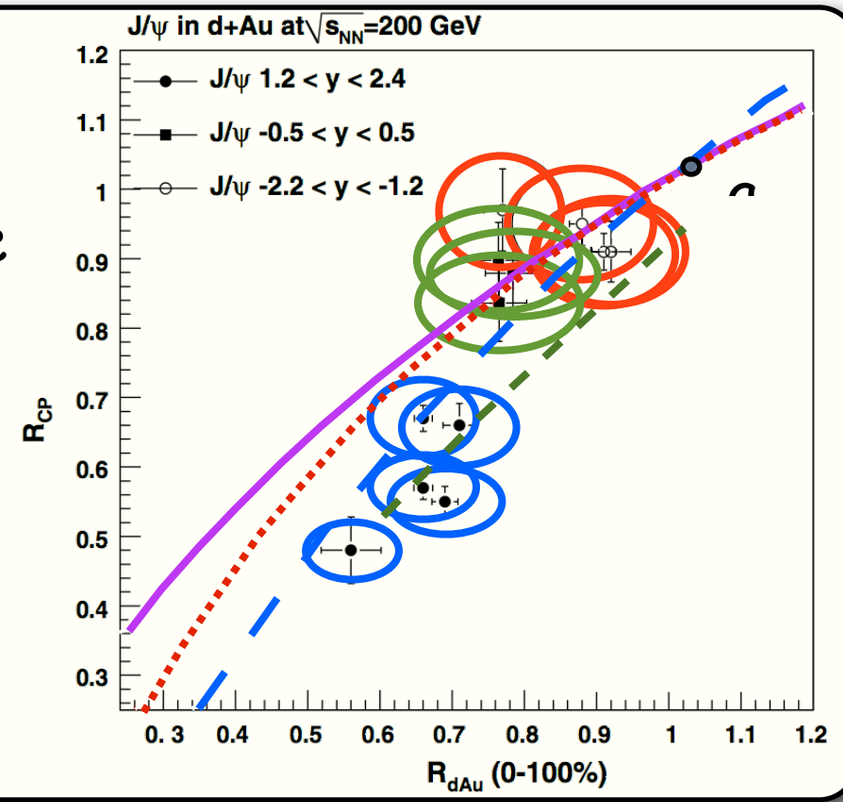
first attempt to track down how gluons are suppressed as a function of the path length in the nucleus using J/ψ

linear

exponential

quadratically

color glass condensate

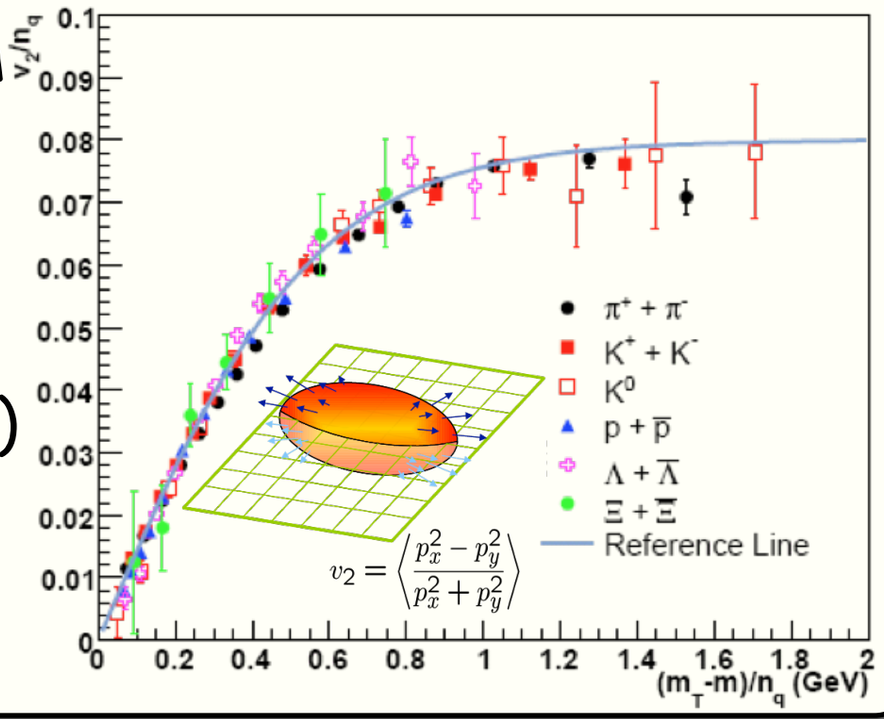


What we observed so far:sQGP

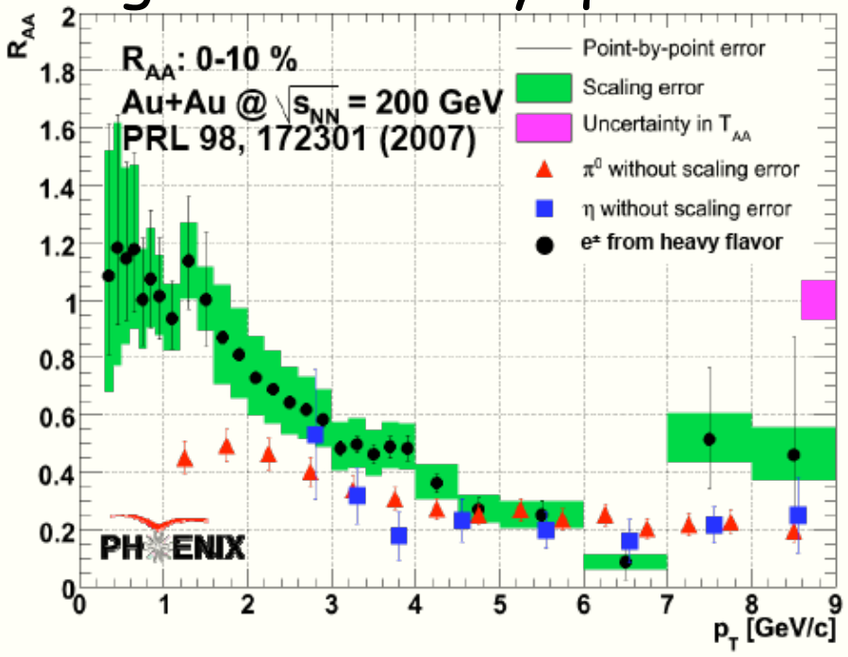
partonic degrees of freedom

Hydro calculations which reproduce v2 of hadrons indicate:

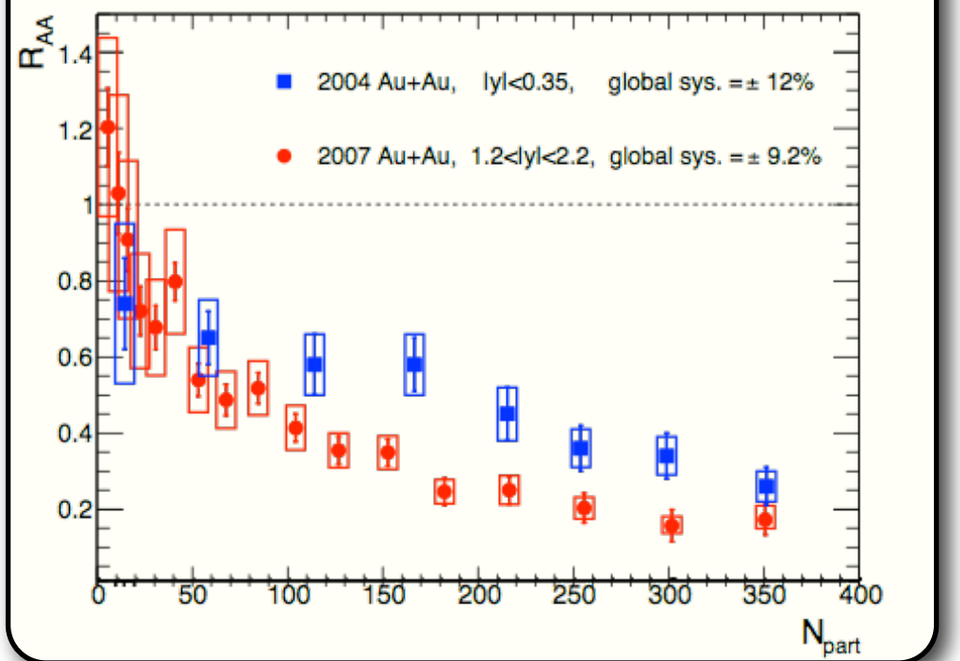
- rapid thermalization (<1fm/c)
- formation of a strongly interacting medium



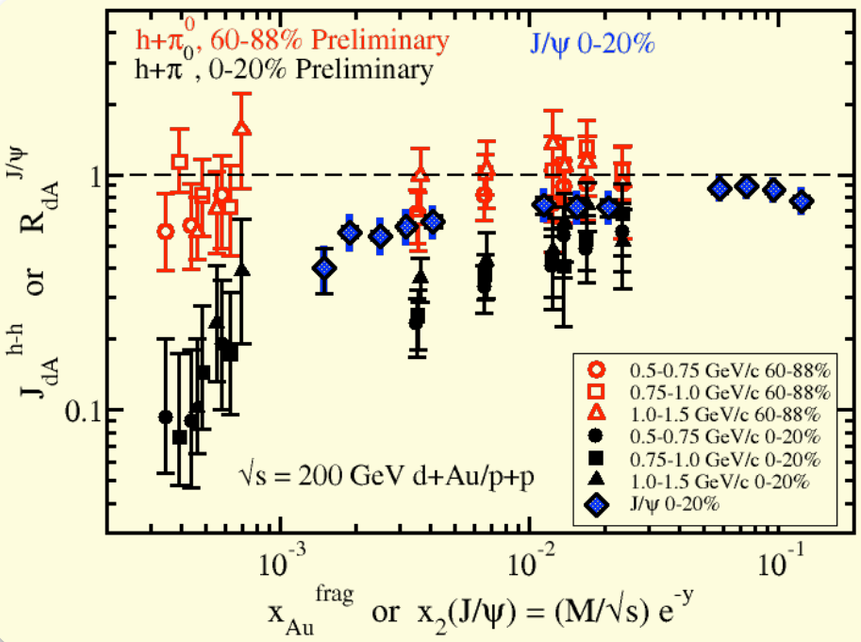
strong energy loss of light and heavy quarks



suppression of heavy quarkonia (J/ψ)



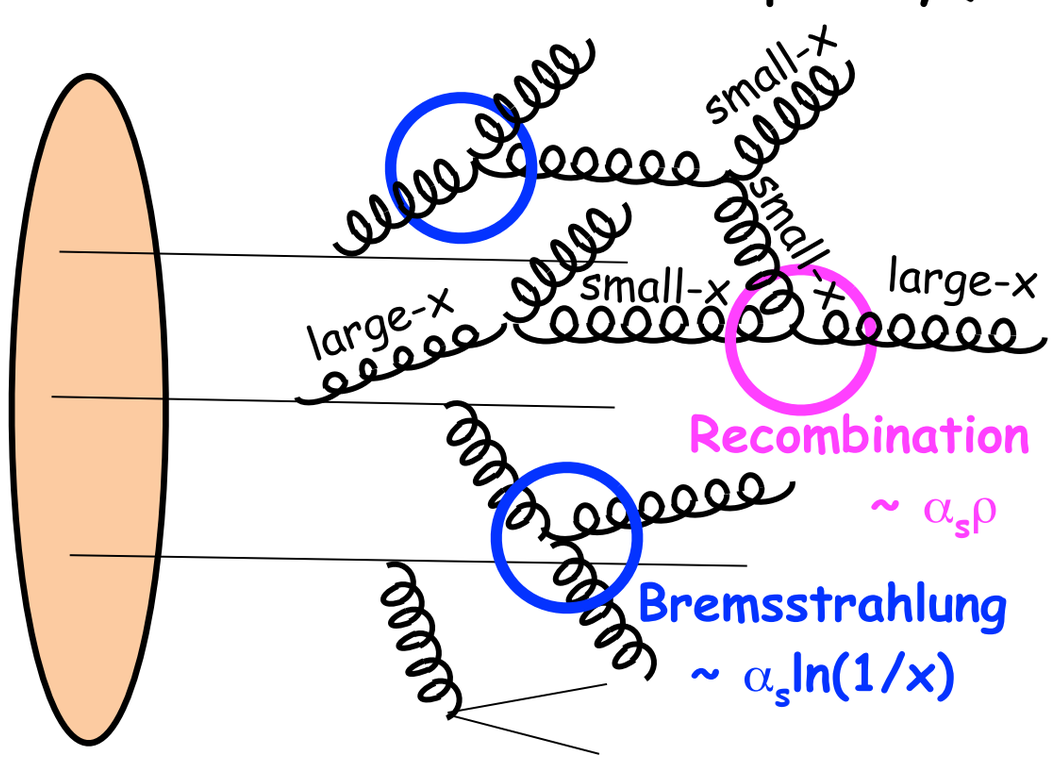
Questions arising from these observations

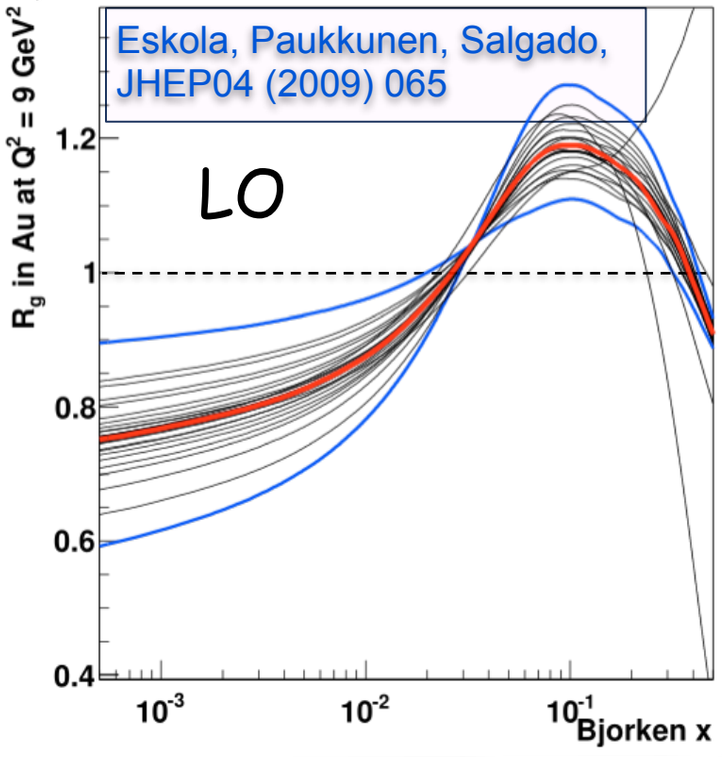


- what is the mechanism behind the large suppression at very forward rapidity?

how to test shadowing and gluon saturation:

- measurement of nuclear modification of particles produced by gluon fusion in p(d)+Au collisions at forward rapidity(small-x)
  - direct photons
  - heavy flavor
  - quarkonia





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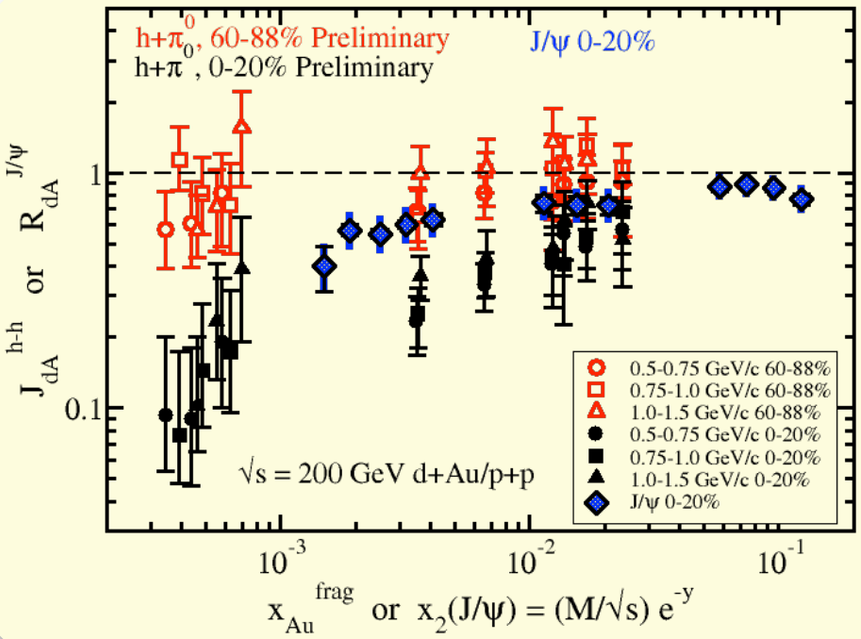

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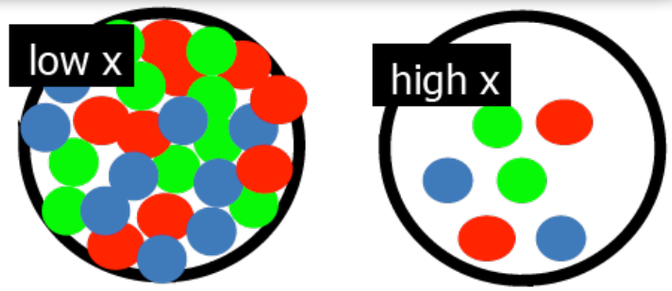
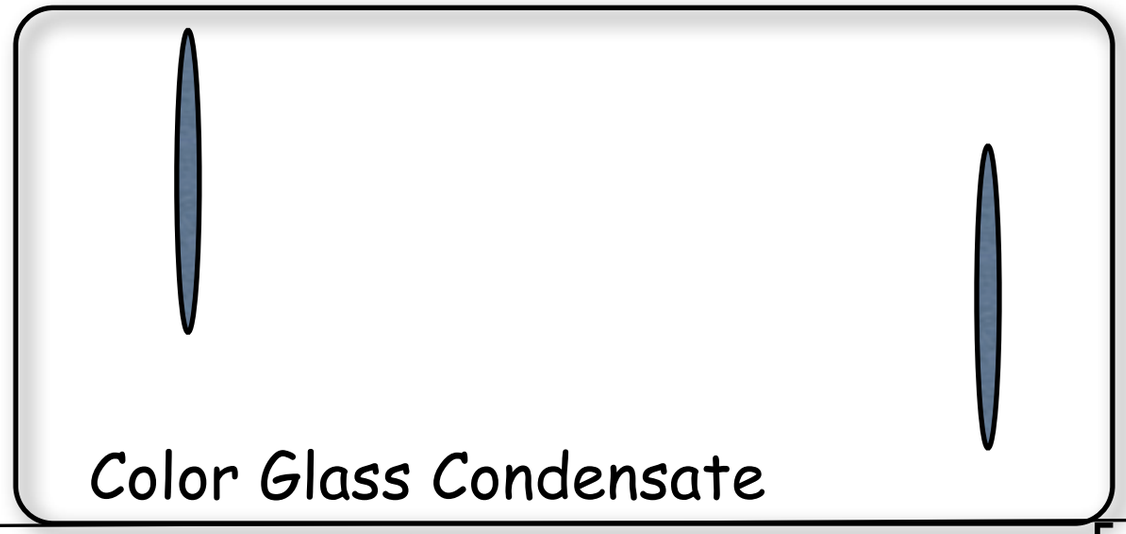
signatures for Color Glass Condensate



- monojets in p(d)+A collisions at very forward rapidity
- twisted bulk medium in A+A, can be probed by azimuthal dependence of jets, larger effect at $\eta \sim 2$ [PRC72 (2005) 034907]



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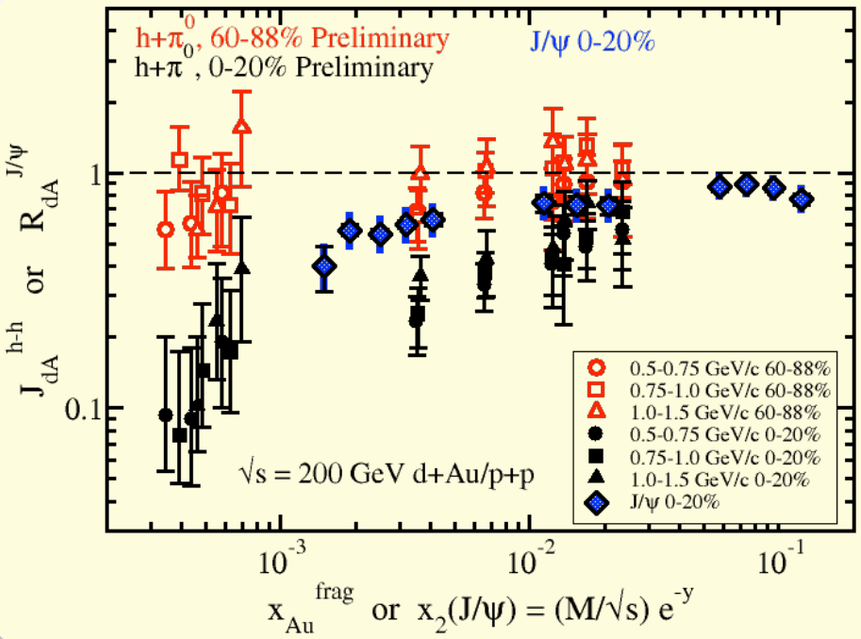

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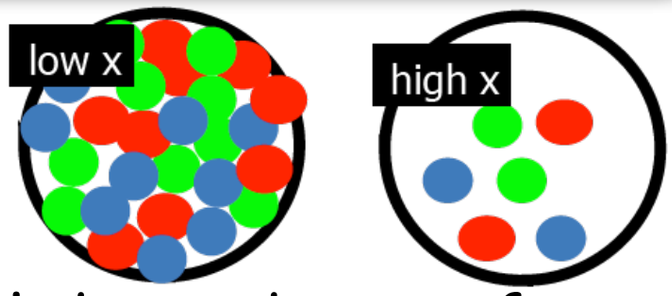

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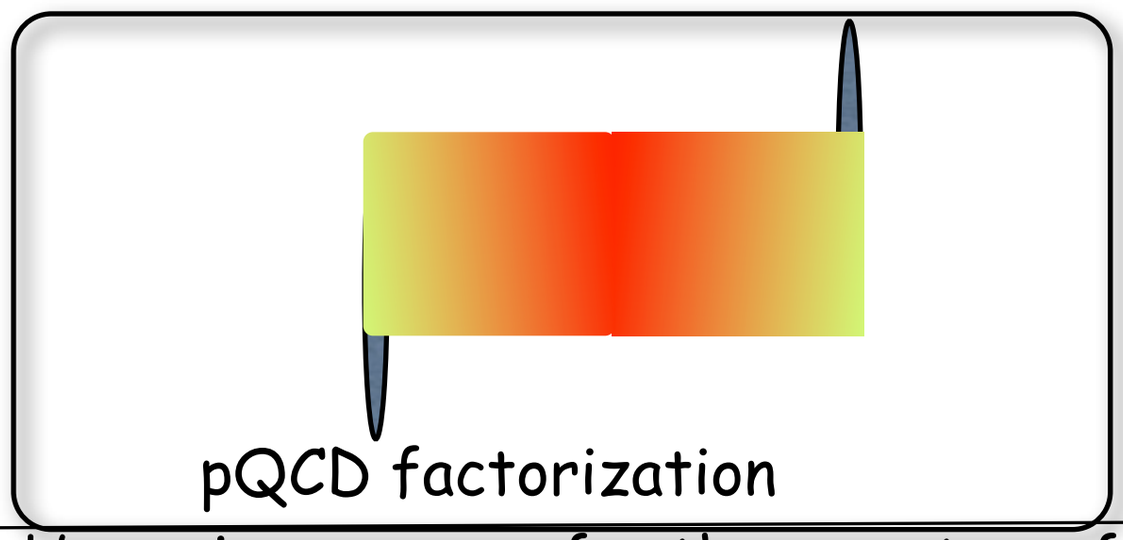

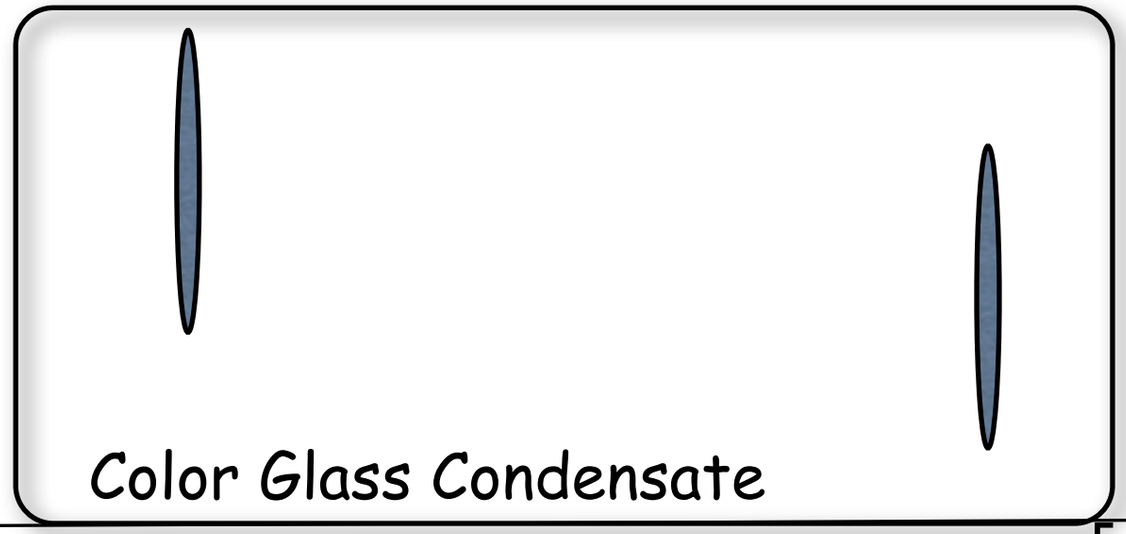

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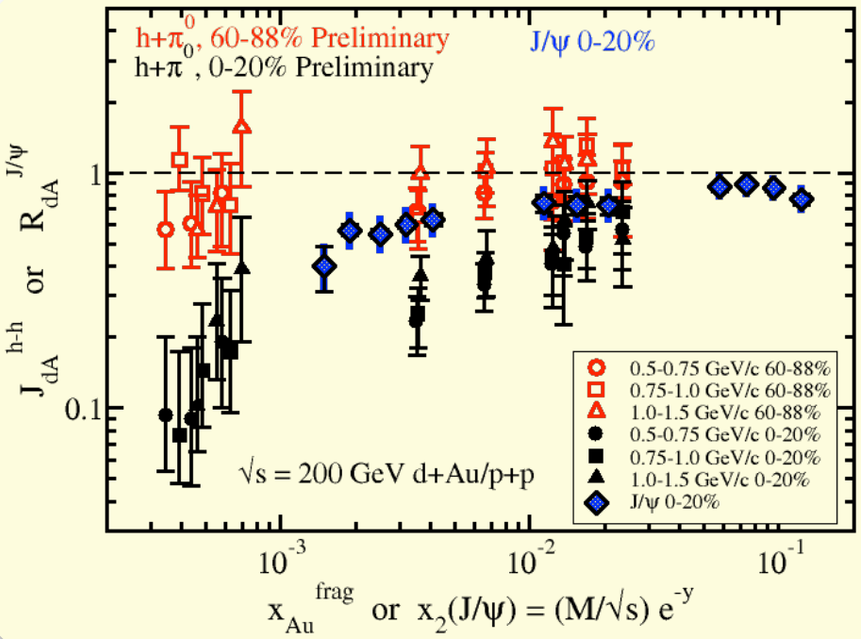

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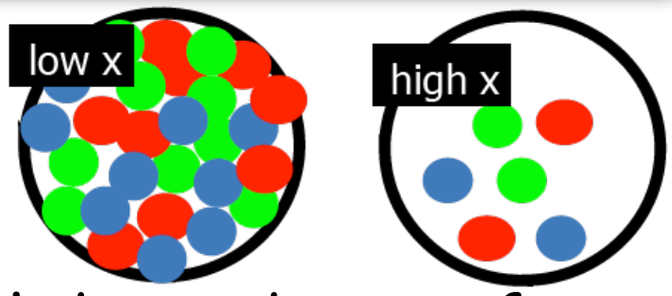

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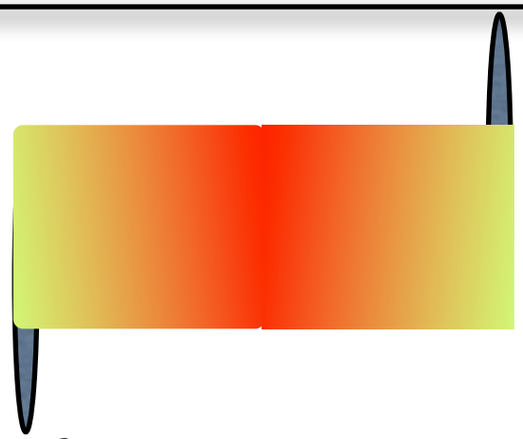
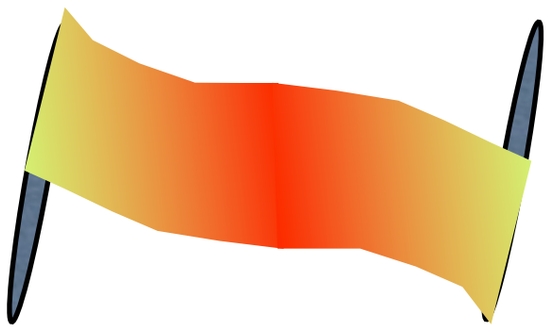


pQCD factorization



Color Glass Condensate

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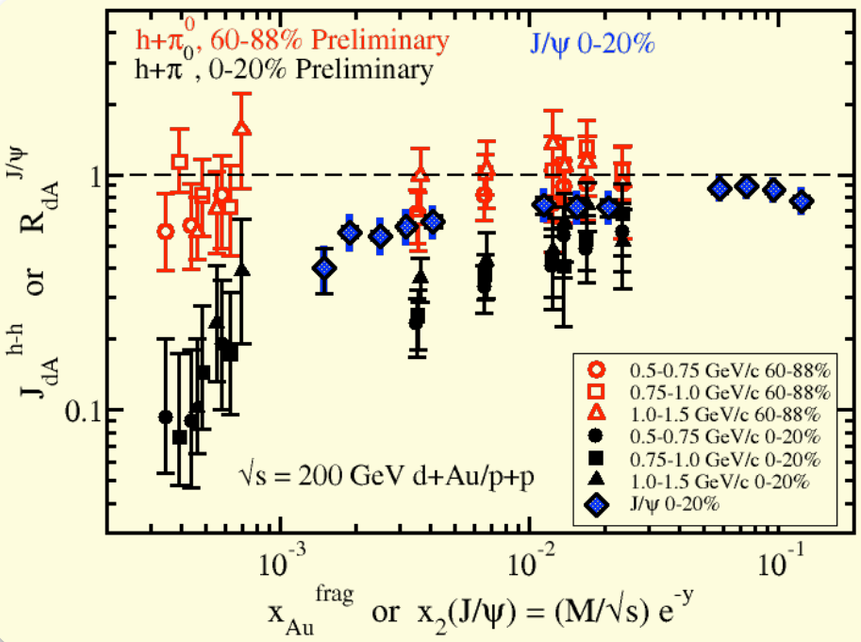
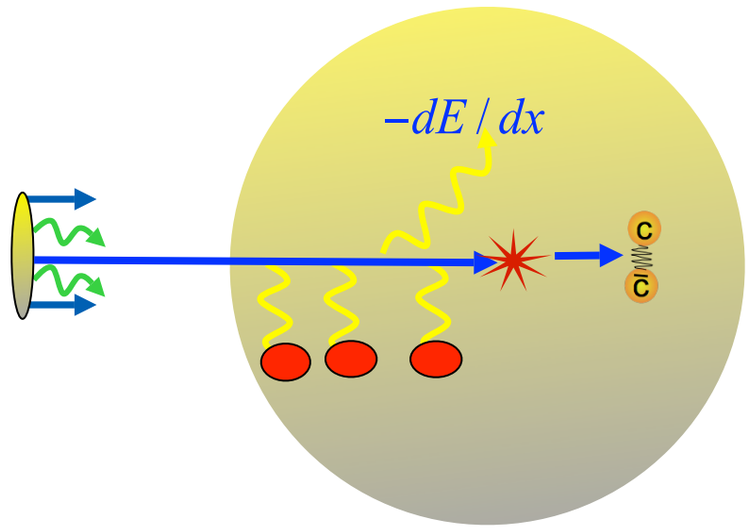


- what is the mechanism behind the large suppression at very forward rapidity?

how to test energy loss of partons:

- nuclear modification of gammas, heavy flavor and quarkonia in p(d)+A collisions
- measuring path length dependence of nuclear modification using probes from early stages (J/ψ, γ, heavy quarks, jets)
- Drell Yan nuclear modification (E906, d+A)



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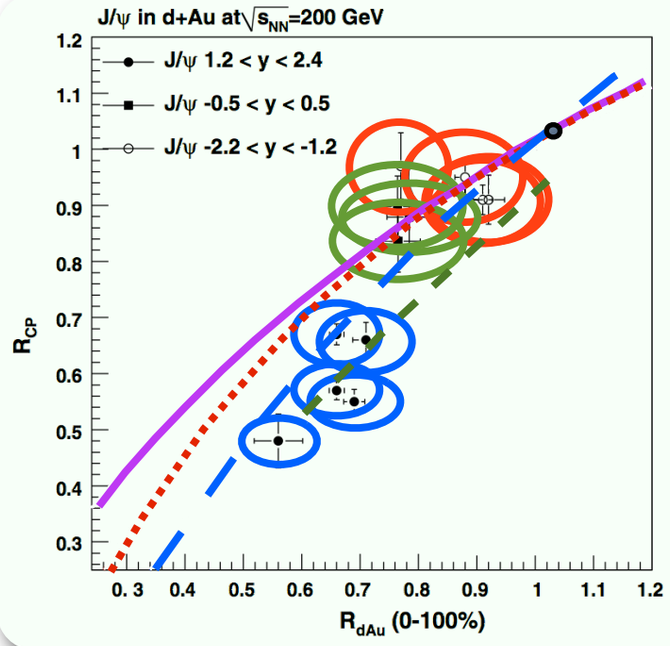
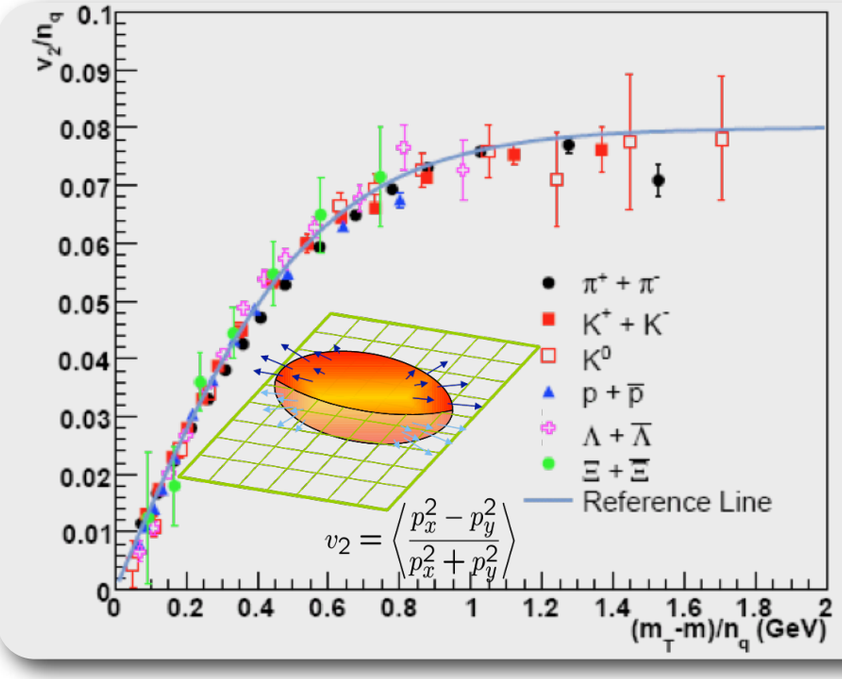


- can the measurement of the path length dependence of suppression be improved?
- what can we learn from it?

- procedure can be repeated using heavy flavor, gammas, jets and light hadrons once calorimetry is available at large rapidity where effects are stronger
- this measurement would provide a strong constraint on the mechanism for parton modifications in the nucleus

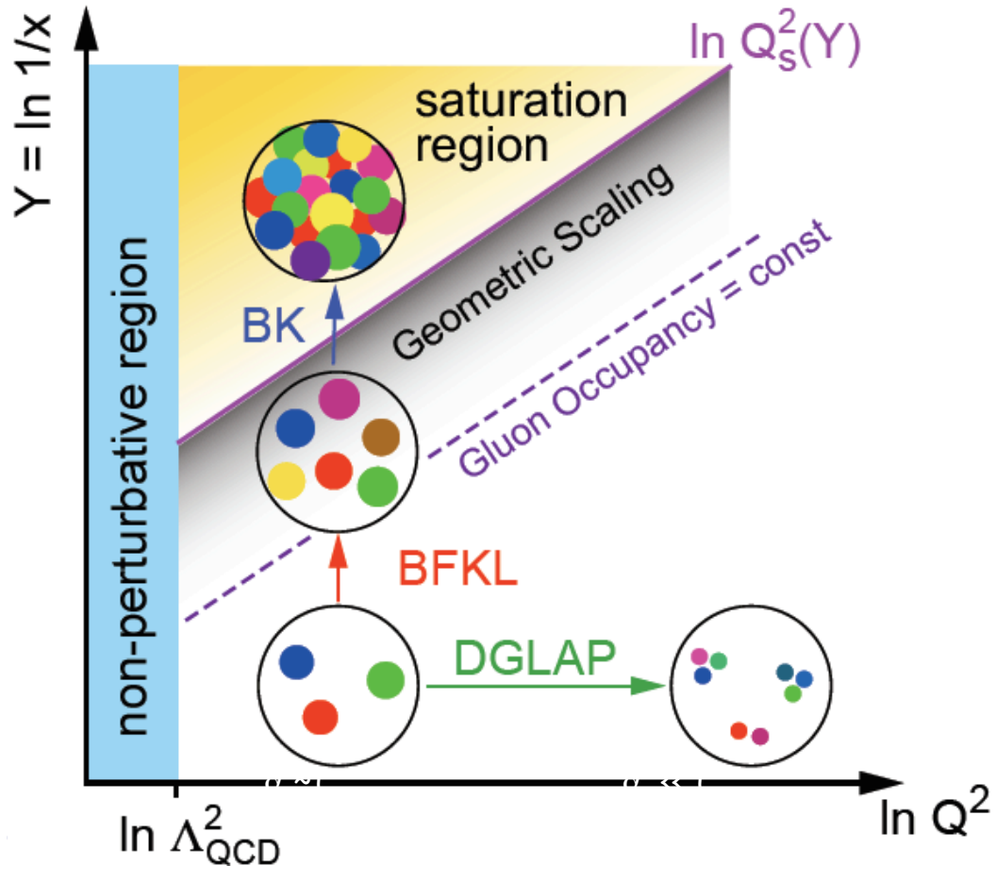
Questions arising from these observations



- why does the system thermalize so fast?
- can we get a better constraint on the thermalization time?
- is there any new physics in the pre-thermalization stage?
- how does the bulk medium expand longitudinally?

need to understand the parton initial state

- need to observe nuclear modifications in very forward rapidity where parton modifications are larger



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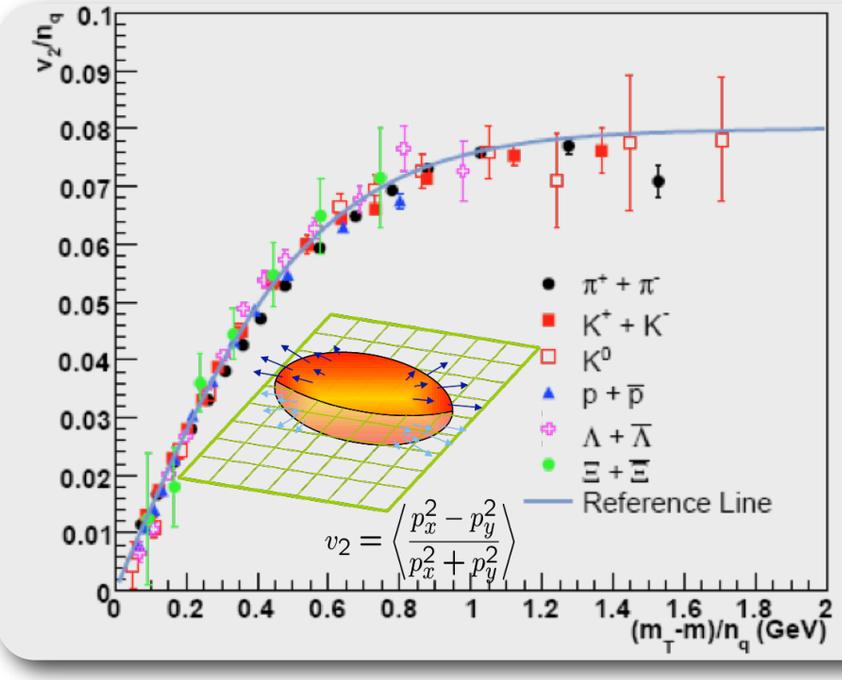

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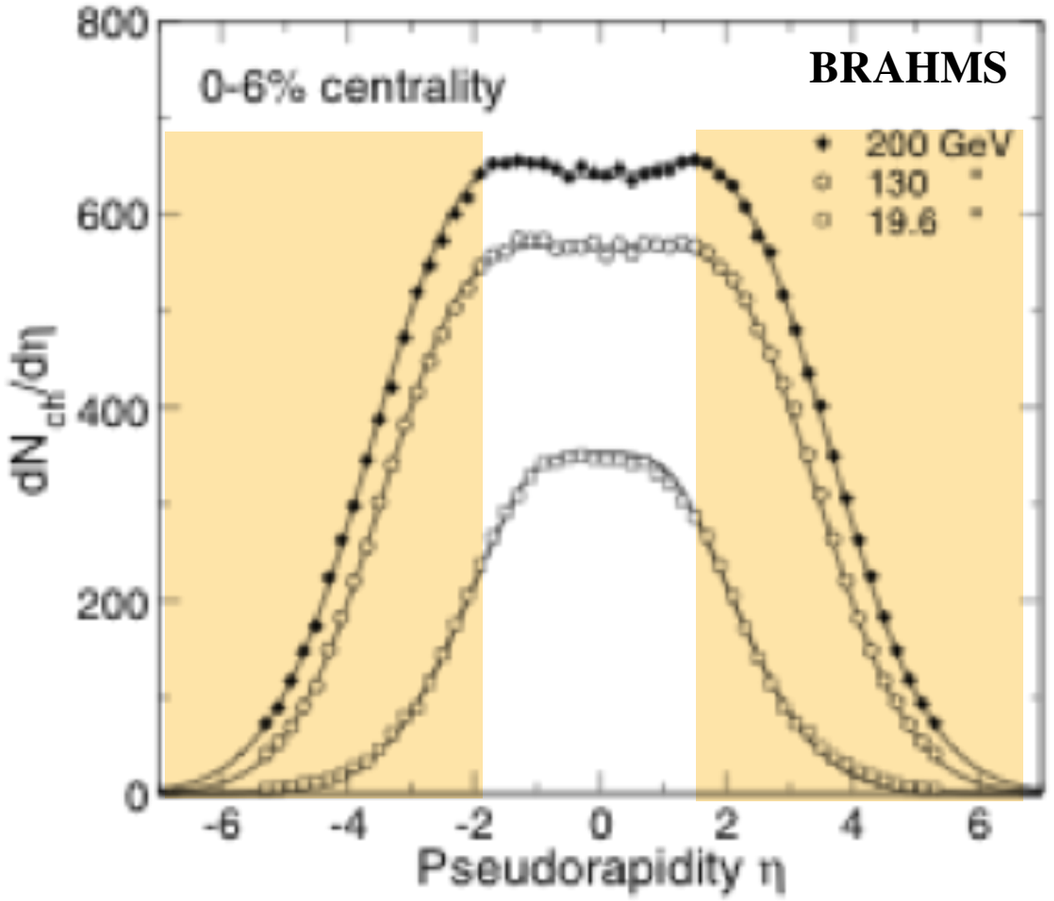
explore the physics outside the Bjorken plateau region

- longitudinal hydrodynamics under-explored to date
- LHC has wider plateau, less access to lower density region
- need to measure flow, energy loss, temperature, color screening



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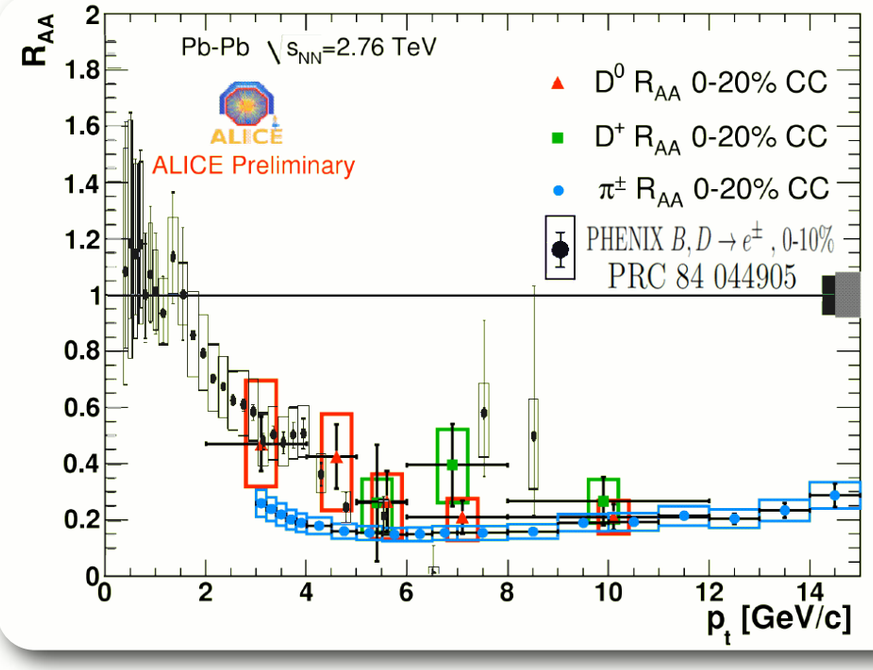
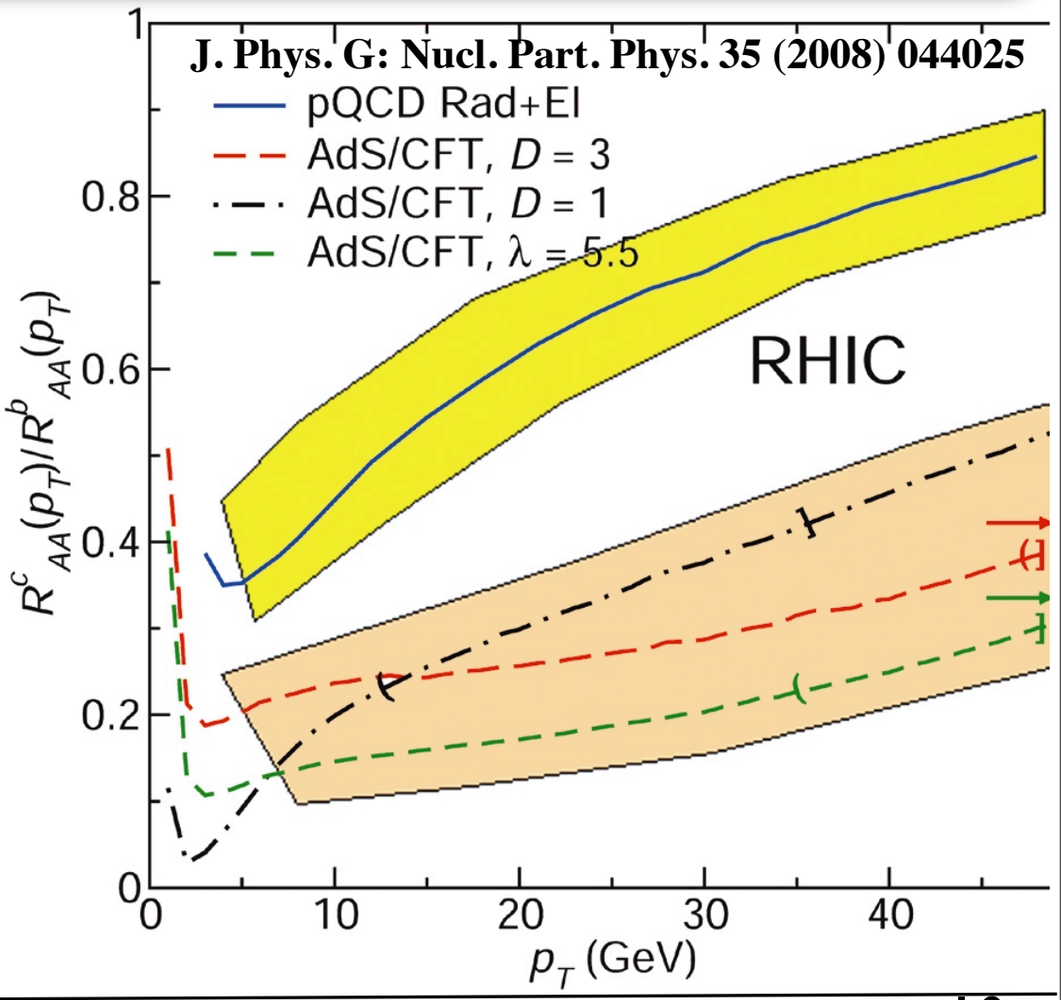


- pQCD radiative energy loss of quarks should depend on the mass of the quark, why is that not observed? no collision energy dependence?
- how do the heavy quarks couple with the medium formed in A+A?
- dE/dx depends on L, L^2, L^3...?

- energy loss scenarios
- can be tested with quark mass dependent nuclear modifications (FVTX program)
- HF tagged jets, HF-hadron or HF-γ correlations can shed light on how HF couples with the medium
- also need to check large rapidities where we can explore different densities at the same beam energy



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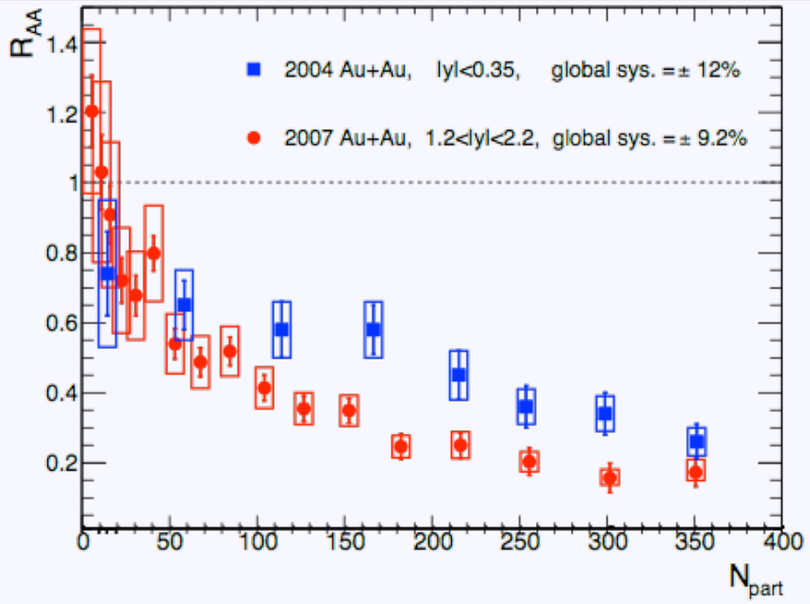
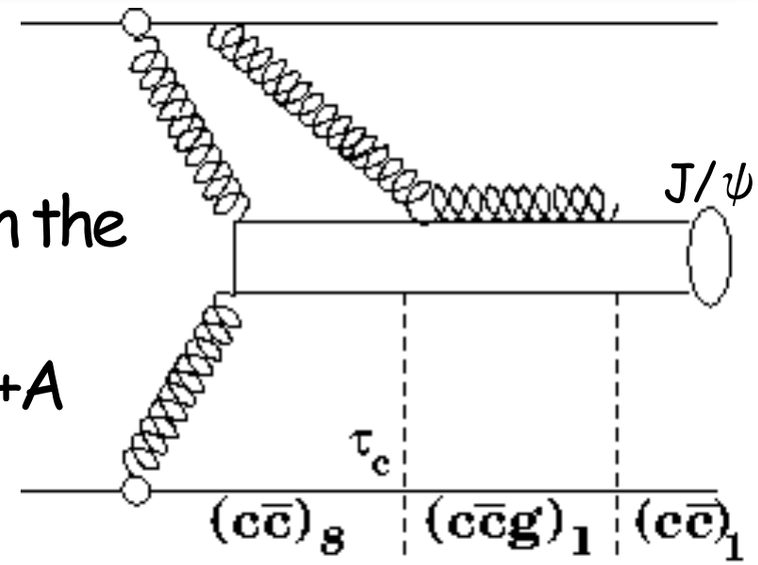


- how does the significant CNM effects observed for quarkonia in d+Au factorize in Au+Au?
- can we obtain color screening and temperature experimentally?
- what is the role of charmonium regeneration?

color screening in QGP: the need to go to forward rapidity

- p+p data favors formation of color octet charmonium
- final state J/ψ and ψ' are formed after crossing $\tau_F = 41\, e^y$ fm in the nucleus rest frame at RHIC [Nucl.Phys.A770,40(2006)]
- that means charmonium is a pre-resonant object above y ~ -2 in p+A



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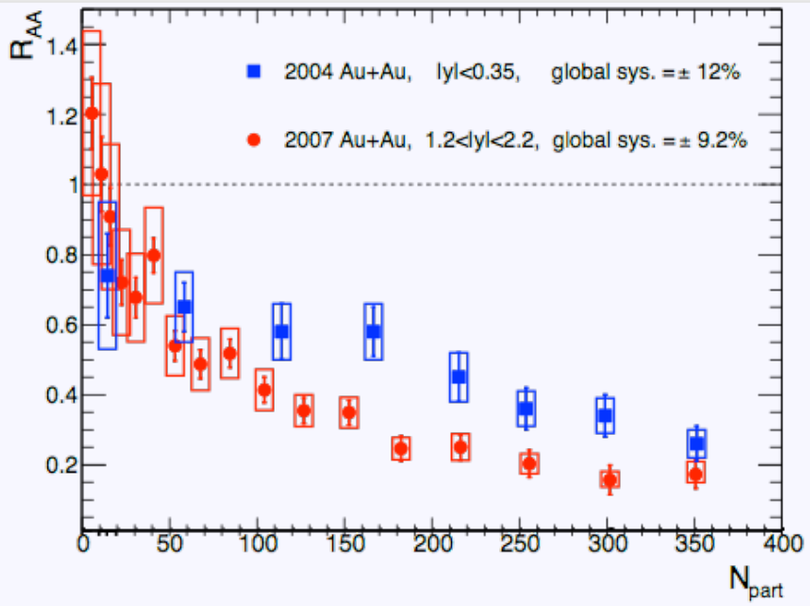

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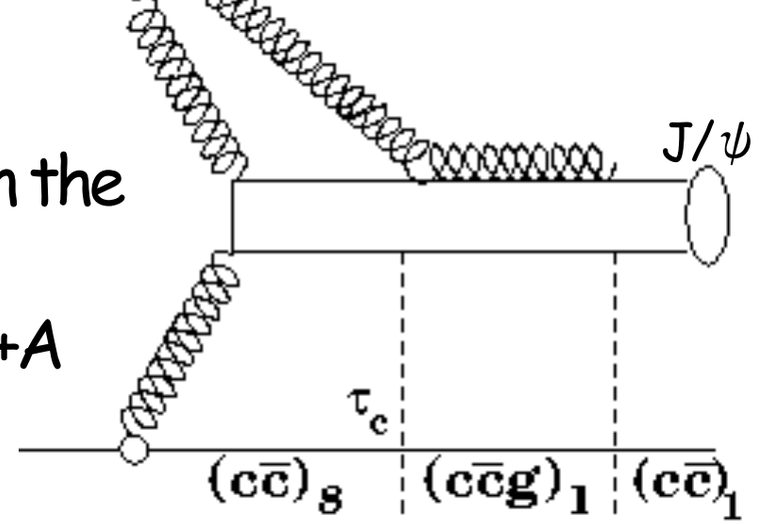
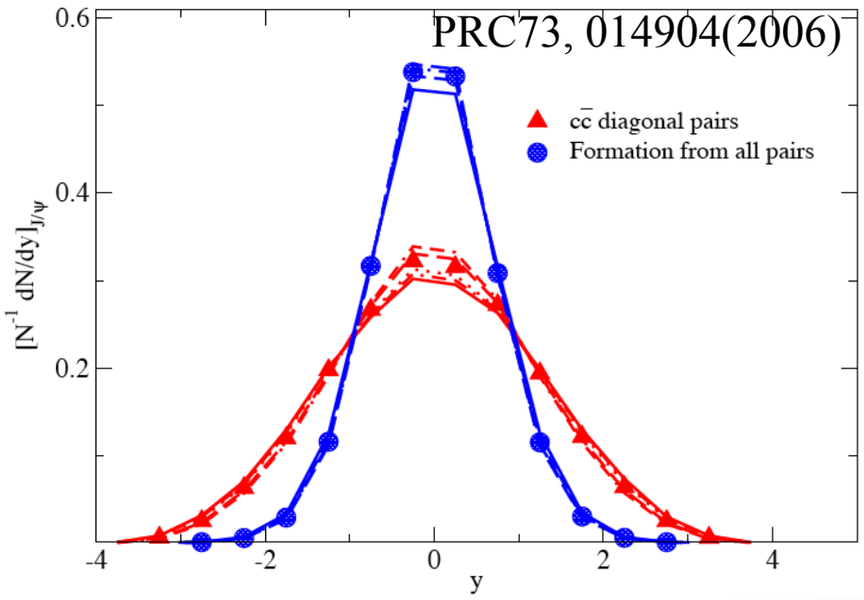
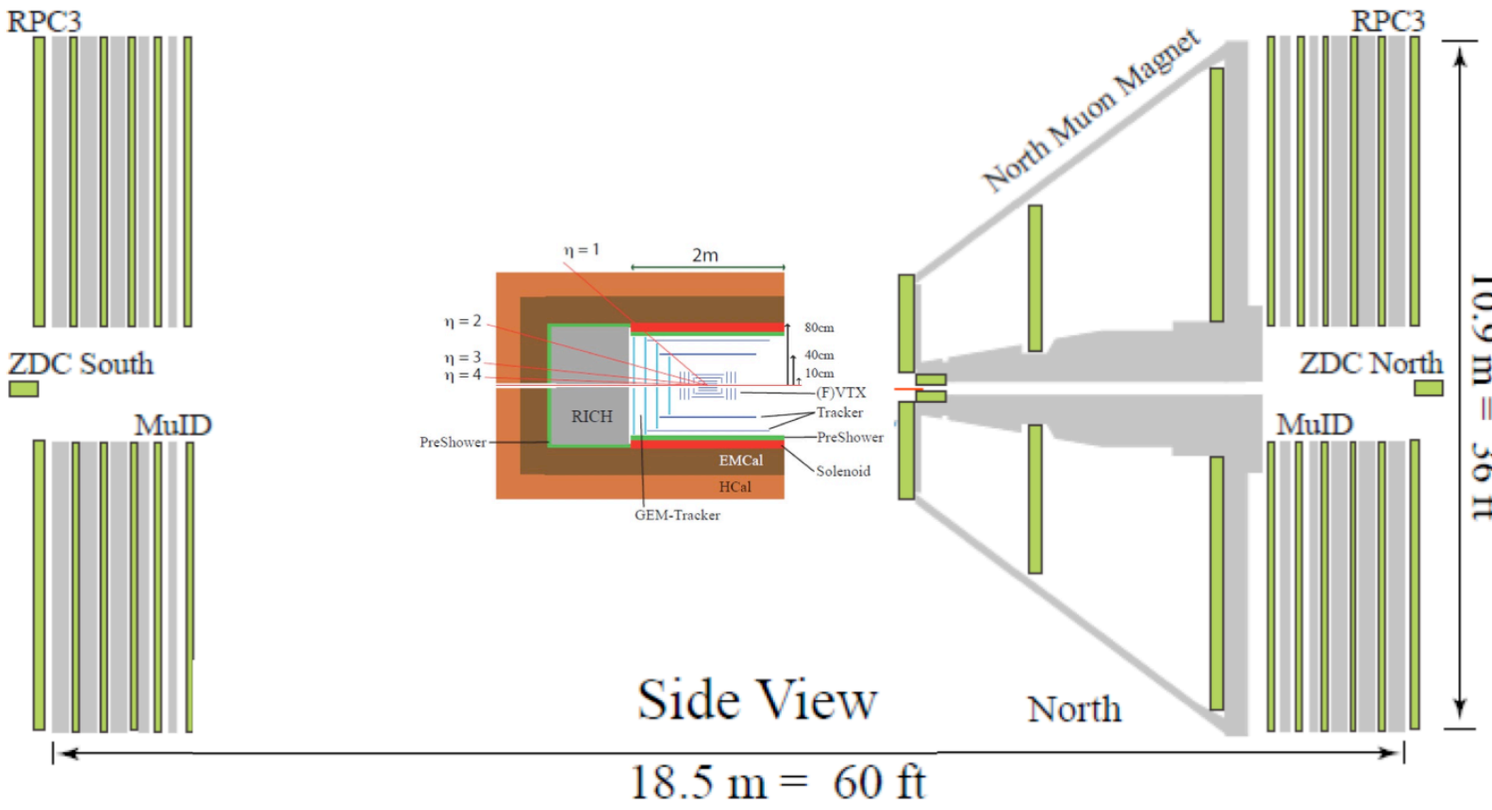




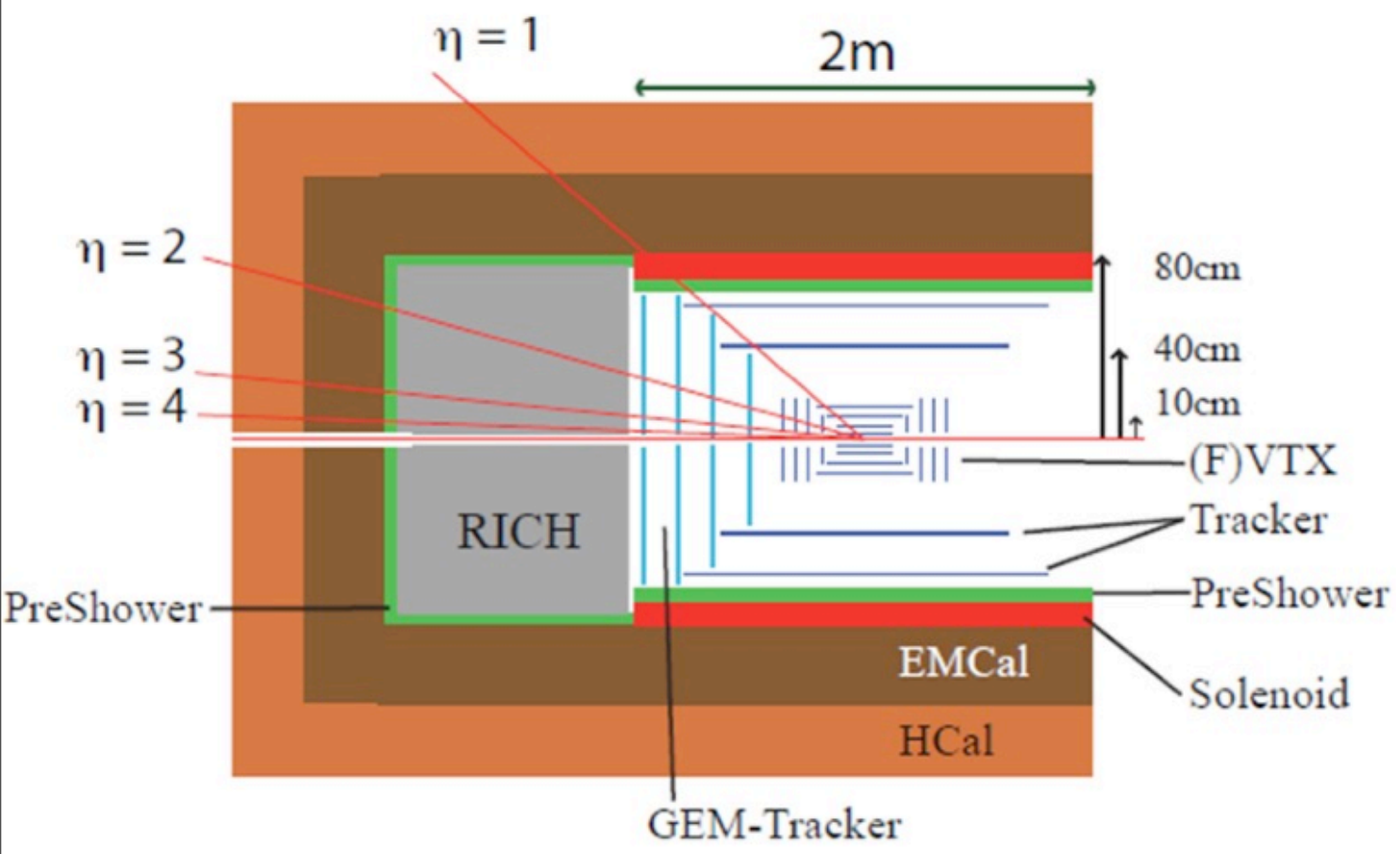
- charmonium regeneration smaller at large rapidity
- color screening + initial state effects more pronounced
- J/ψ-hadron correlation can help to isolate initial state effect

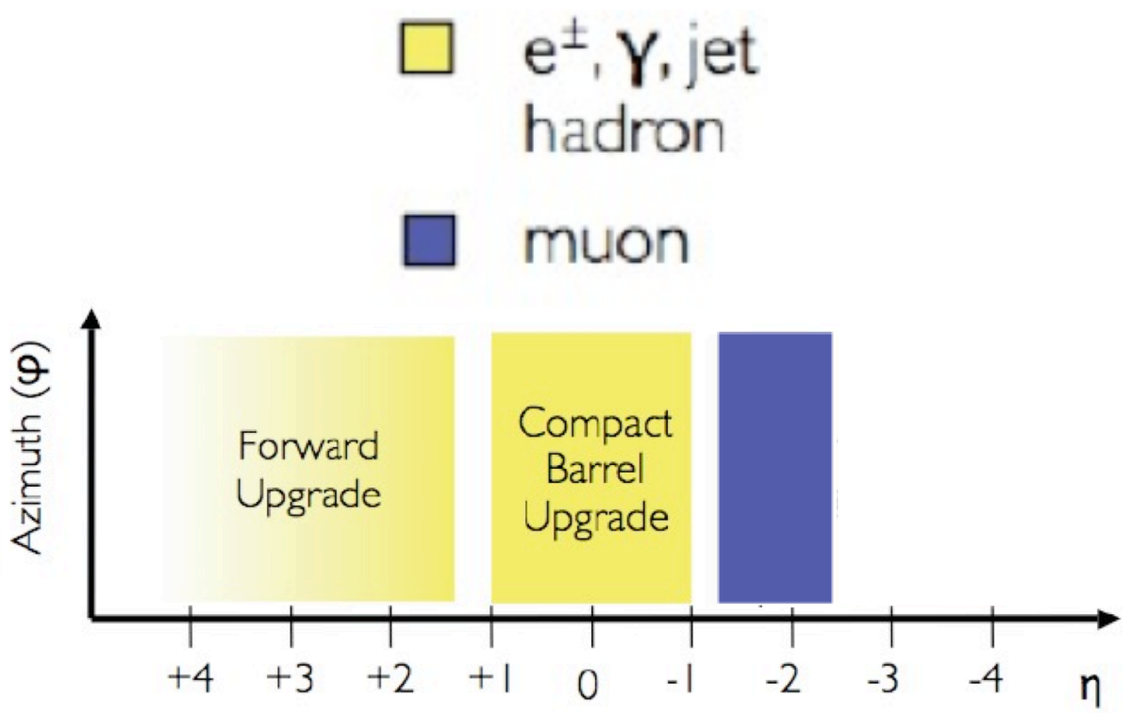
sPHENIX: Conceptual Design



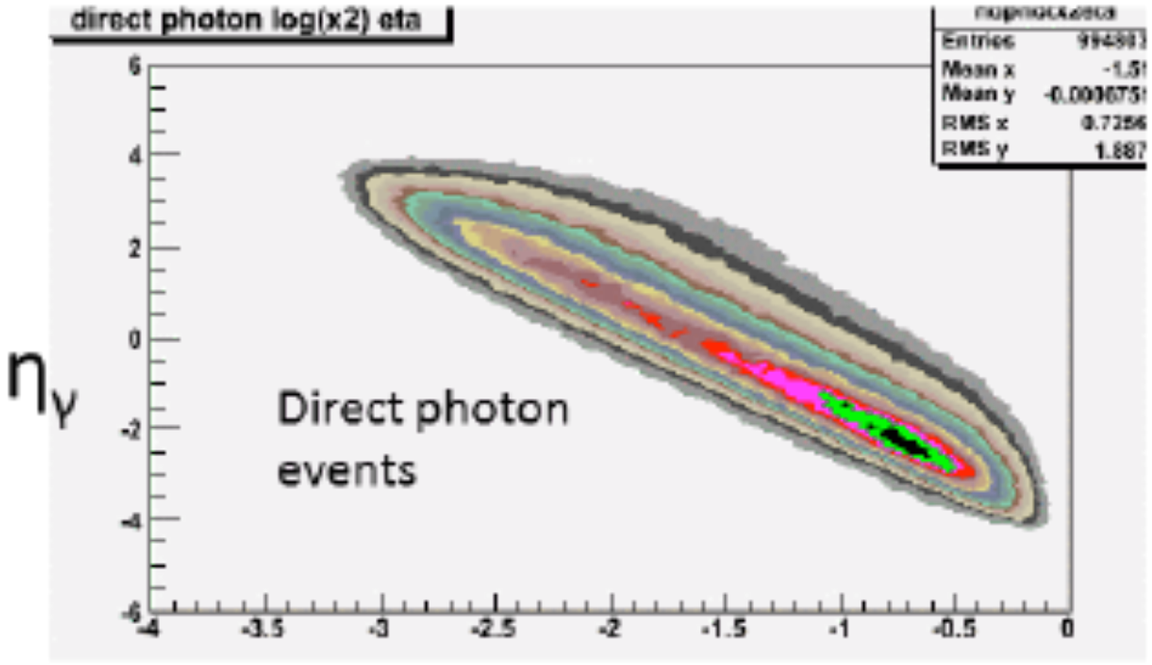
RHIC already provides flexible beam configurations for path length and density variations

- Au+Au, Cu+Au, d+Au, d+Cu, U+U,...
- 19 < collision energy[GeV] < 200



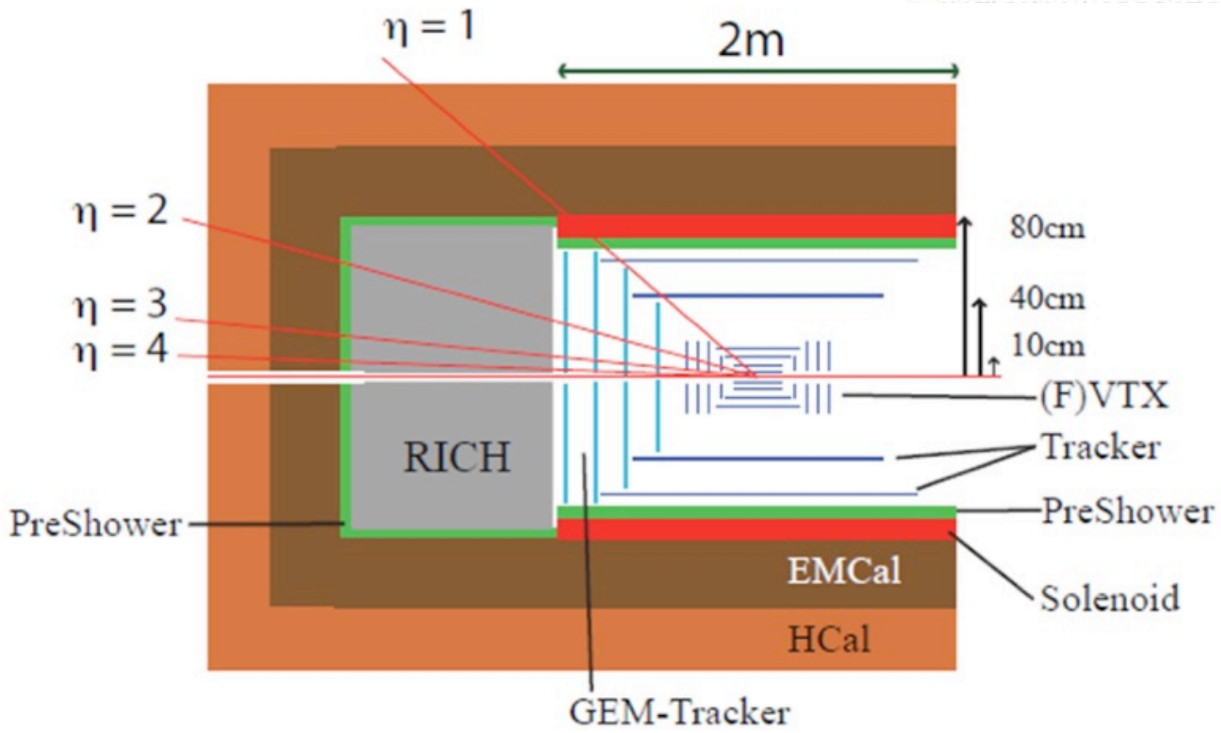


Detector needs



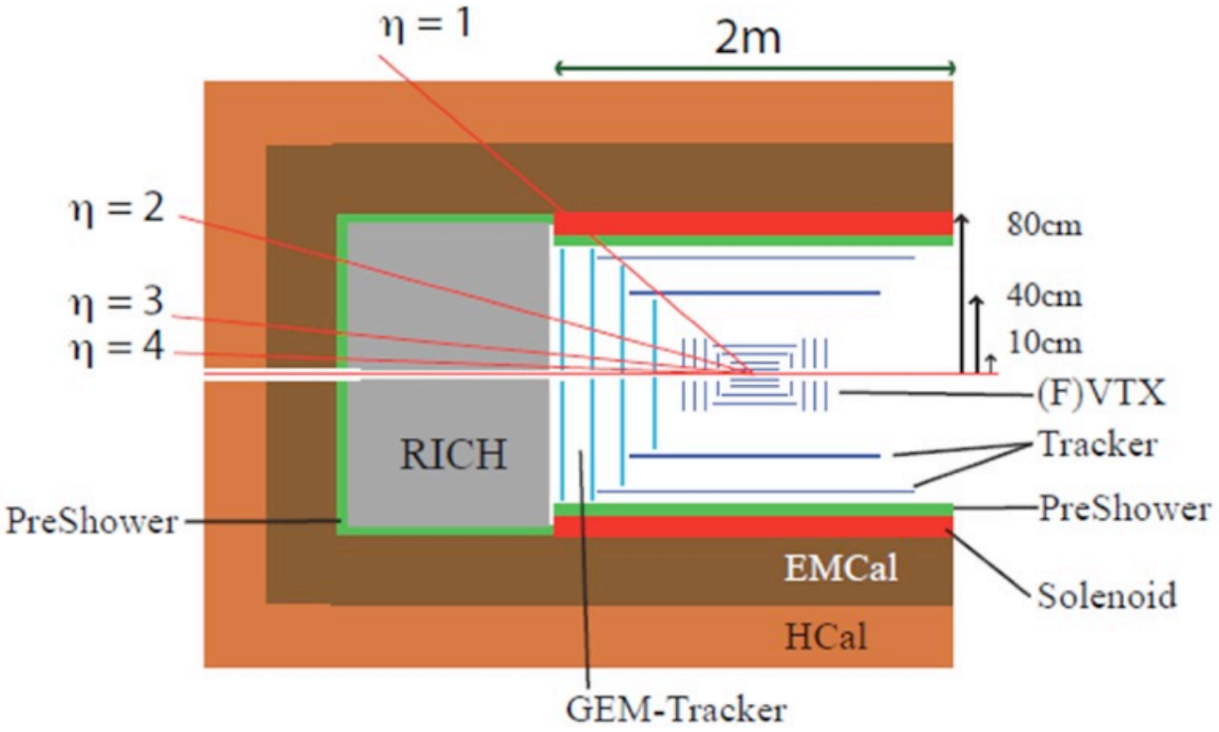
if γ is correlated to pion

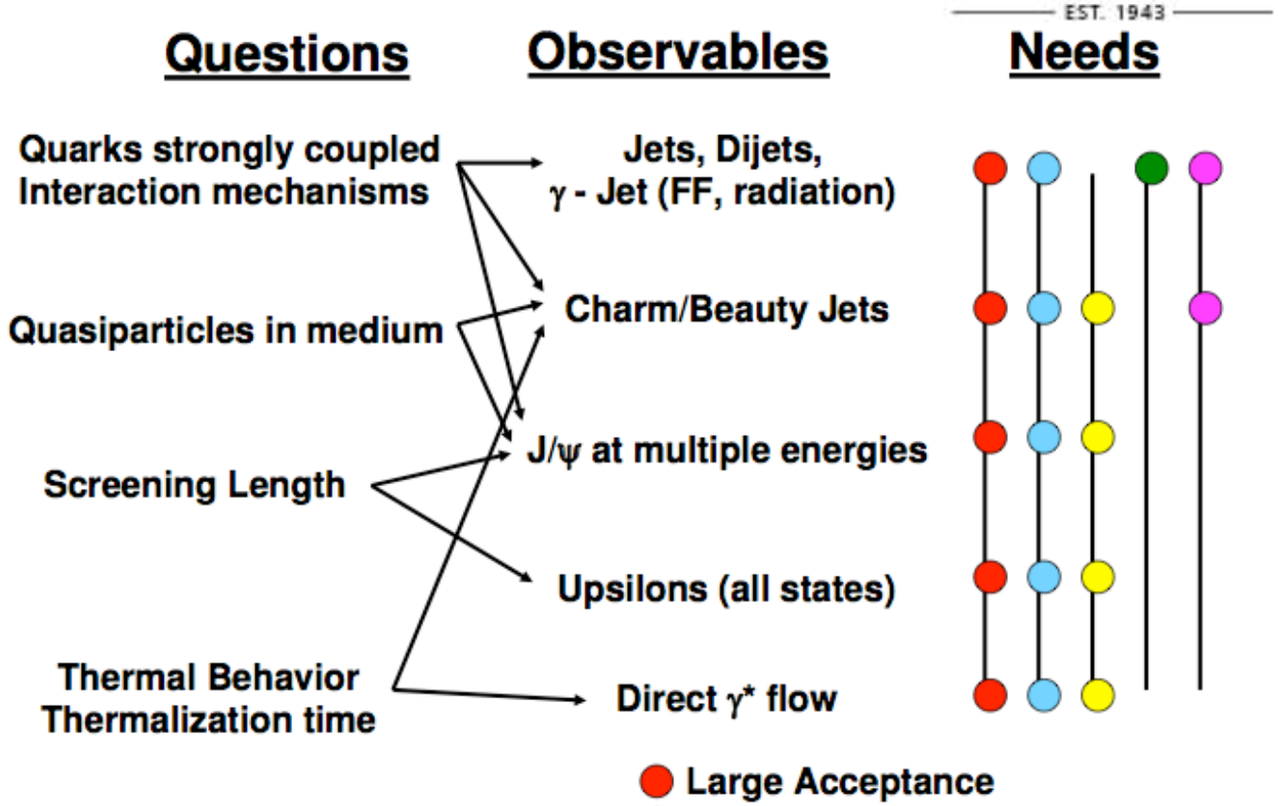
$$x_2 = p_{T\gamma}(e^{-\eta_\gamma} + e^{-\eta_\pi})/\sqrt{s}$$



- full azimuthal coverage, high segmentation calorimetry for jet reconstruction and photon identification
- 2Tesla + high resolution tracking to discriminate J/ψ , ψ' and Upsilon states
- acceptance down to 2deg. next to beam pipe for large rapidity->small-x(~10^{-3})
- particle identification

Detector needs and LANL work task

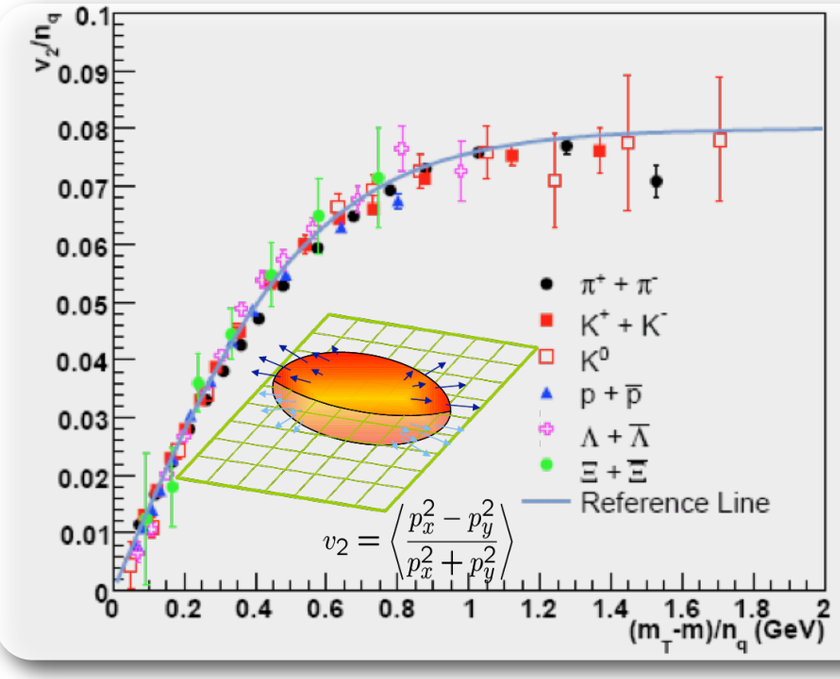




- Xiaodong, Mike, Ming, Christine, Jin Huang and I(starting) are involved in sPHENIX/ePHENIX workshops where conceptual design, physics goals and budget are discussed
- LANL driven by forward physics and is pursuing the hardware at large rapidity and high occupancy environment
- plan for R&D following by assembly in five years
- **important and unexplored physics to be studied at large rapidities!**

EXTRA SLIDES

Questions arising from these observations



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scenarios for the rapid pre-thermalization stage

- fluctuation and turbulence of strong QCD fields
[PLB393,26(1997)][PRL94,102303(2005)][PRC81,024905(2010)]
  - signature: increase energy loss of early jets
  [PRC78,064906(2008)]

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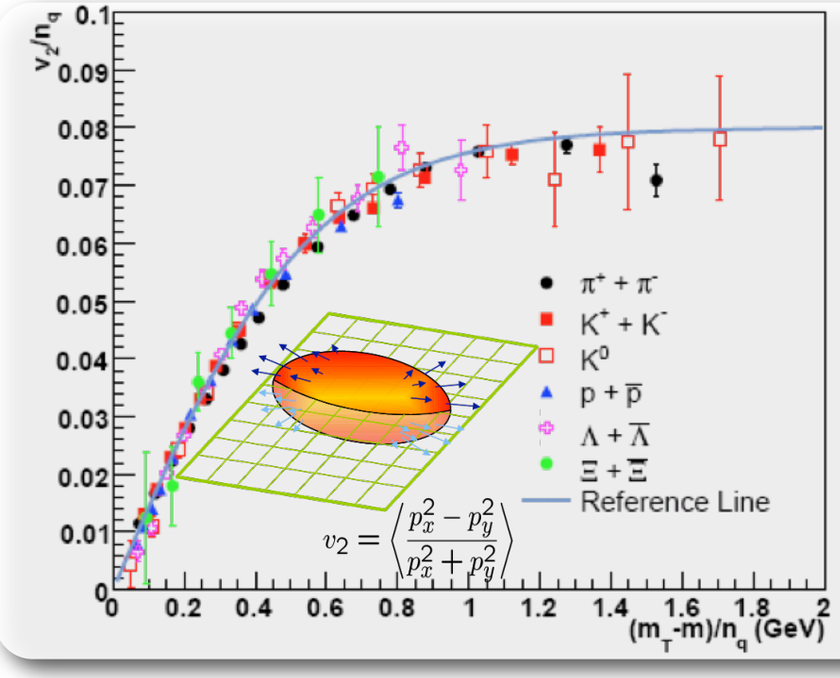

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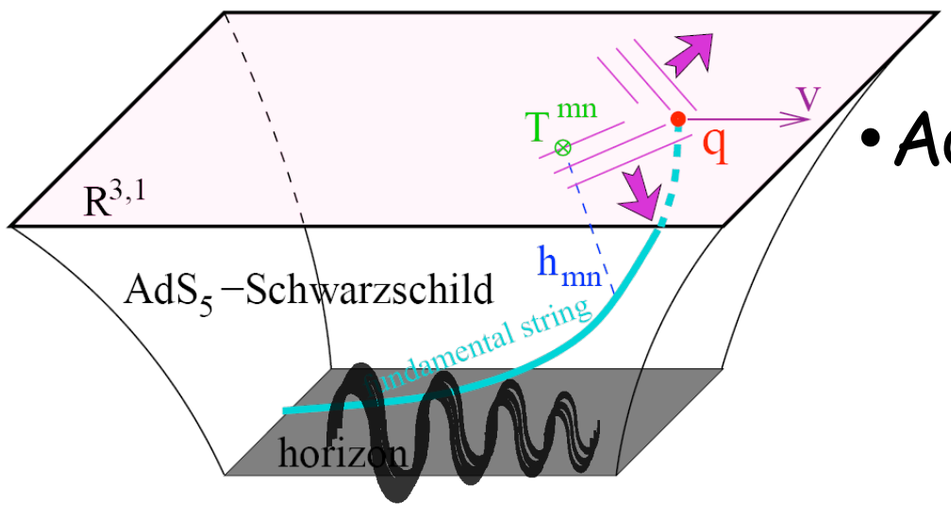
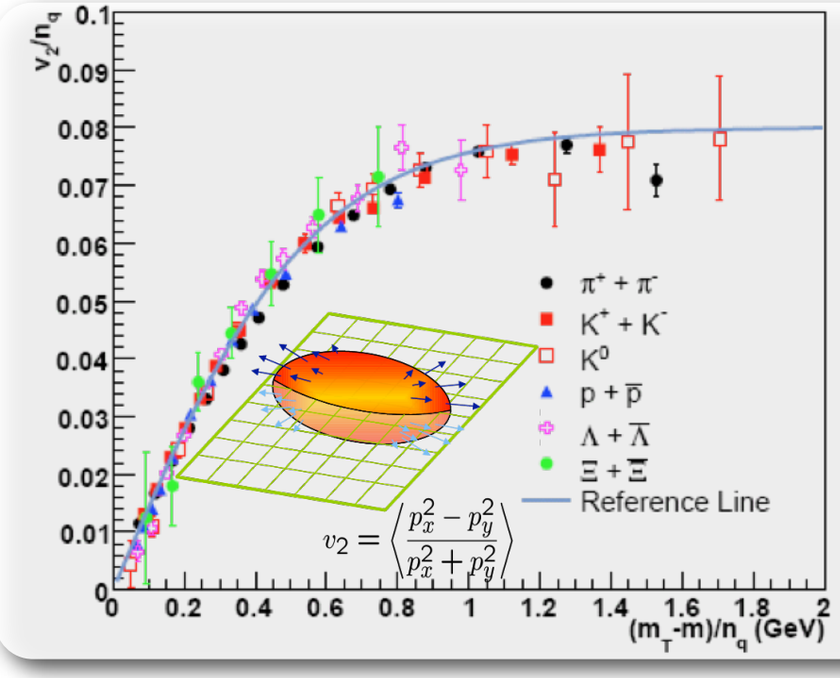


- AdS-black holes/branes oscillations
  - signature: produce low mass energetic dielectrons

[http: //indico.cern.ch/contributionDisplay.py?contribId=24&confId=72423.]

Questions arising from these observations



- why the system thermalize so fast?
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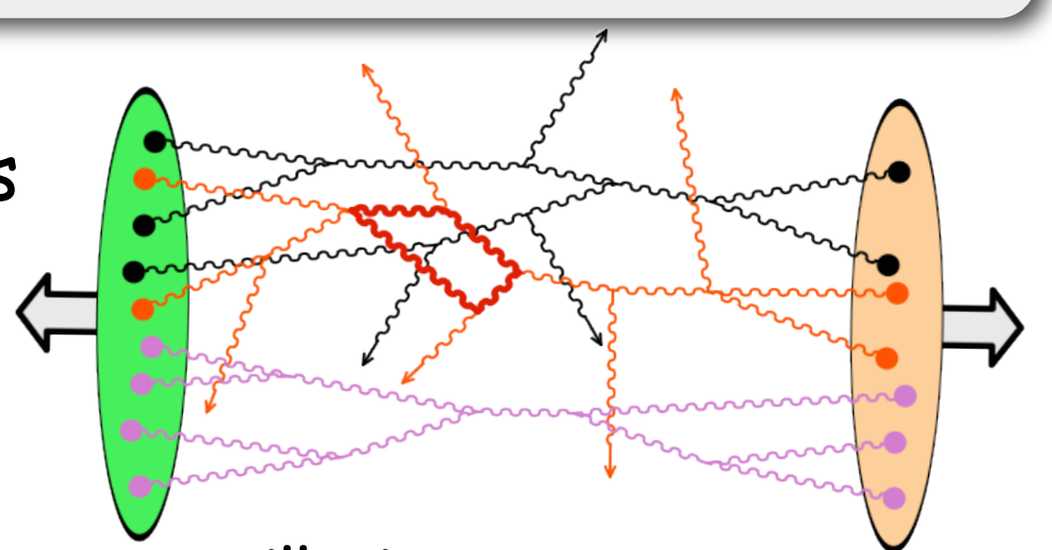
- how the bulk medium expands longitudinally?

scenarios for the rapid pre-thermalization stage



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[PLB393,26(1997)][PRL94,102303(2005)][PRC81,024905(2010)]
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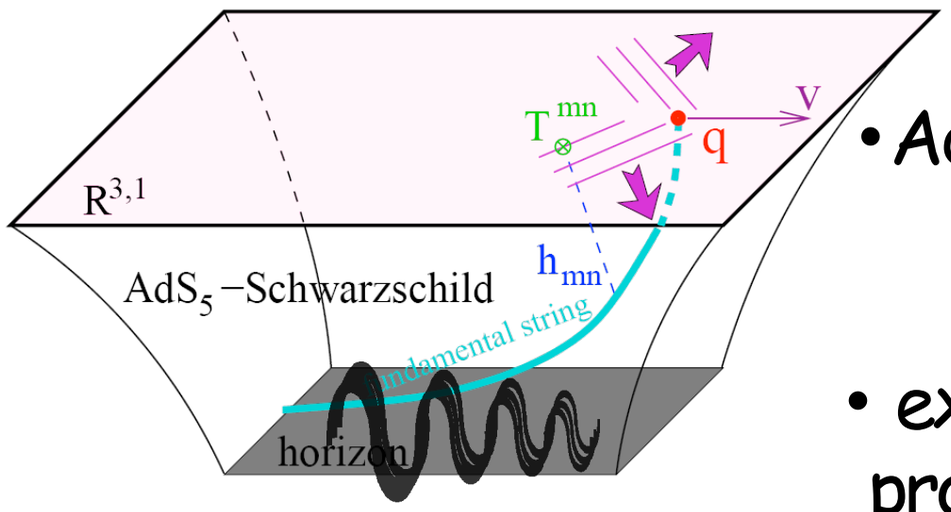

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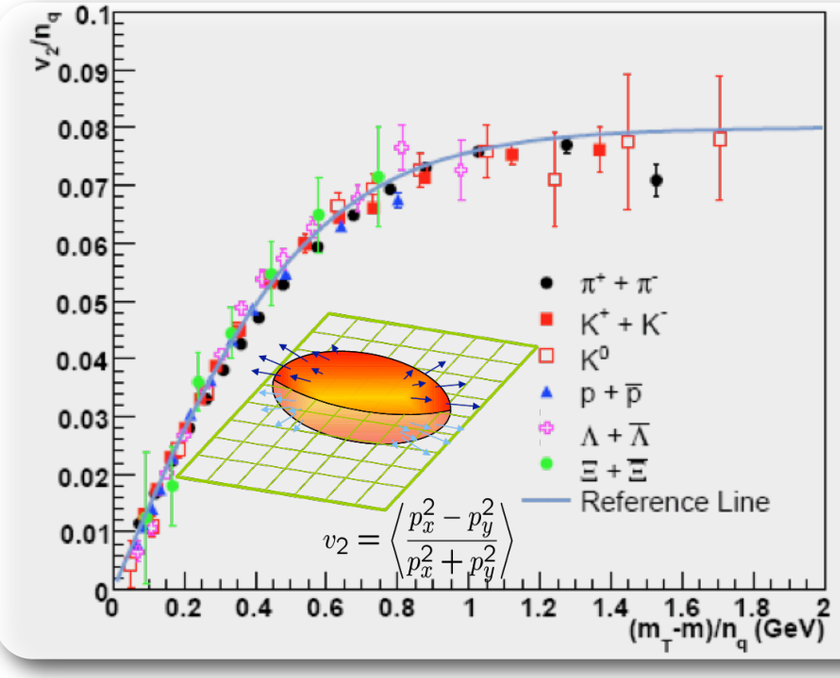

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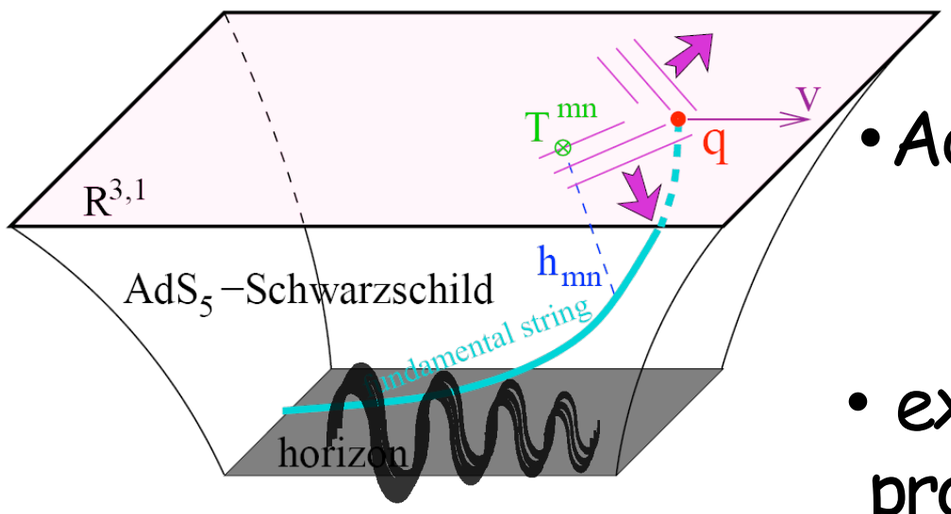

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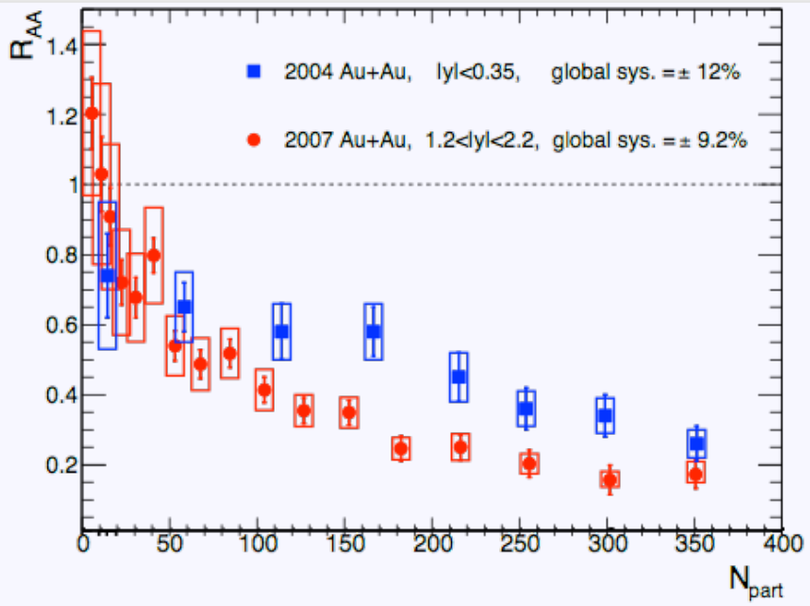
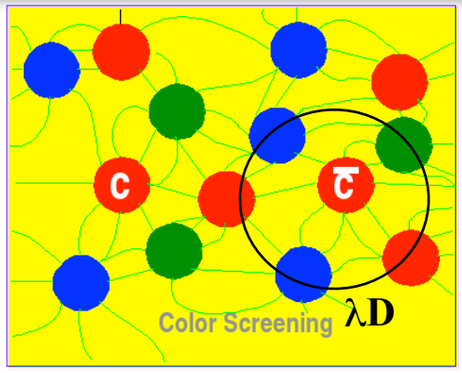
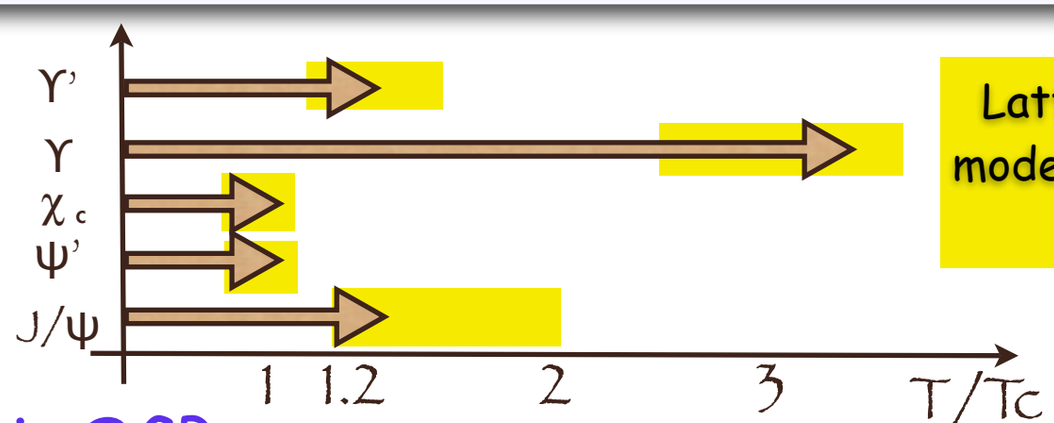


- how the significant CNM observed for quarkonia in d+Au factorize in Au+Au?
- can we obtain color screening and temperature experimentally?
- what is the role of charmonium regeneration?





Lattice and potential model spectral function estimations

quarkonia melting and regeneration in QGP

- needs $R_{AA}\left(N_{coll}, p_T, \phi - \mathrm{RP}, \mathrm{rapidity}, \sqrt{s_{NN}}\right)$
  - dilepton channels J/ψ , ψ',Υ 1S,2S,3S
  - radiative decay: χ_c->J/ψ + γ

charmonium regeneration